Description

Camera with adjustable focus

The present invention relates to a camera which can preferably be used in mobile terminals such as mobile radio devices for example.

Miniaturized cameras are needed for mobile terminals, such as third-generation mobile radio devices.

Known cameras are equipped with an adjustable lens. An adjustable lens requires a complex, mechanical adjustment mechanism. Such mechanical devices are however cost-intensive, relatively large and susceptible to mechanical effects such as shocks and dust (wear).

All ex-works focused cameras (all fixed-focus systems) have the disadvantage that the focusing of the lens during assembly of the camera is a cost-intensive business. This also represents the greatest weakness as regards delivery quality for mass production.

Furthermore the use of autofocus controls is known for cameras in which the lens is moved for focusing electrically, magnetically or by a motor. Such controls are however susceptible to faults, are not stable, need a great deal of energy and take up a lot of space. However, when the camera is miniaturized for mobile applications it is desirable to integrate autofocus functionality into the camera.

The present invention is thus based on the object of providing a camera which can be embodied as a miniature design, only has a low power consumption and yet is not susceptible to mechanical effects,

and which allows a hermetically dust-proof construction with low overall costs. In addition, for use in mobile terminals, the camera should be able to be integrated into a housing which offers sufficient protection against environmental effects.

This object is achieved by a camera with the features of Claim 1. Preferred developments of the present invention are produced by the dependent claims.

The camera features a housing, a lens, a sensor as its focal plane, a piezo element for displacing the sensor and connecting elements for making contact with the sensor. The piezo element is arranged below the sensor and the lens is mounted in the camera in a fixed way, especially in the camera housing.

In a preferred embodiment of the present invention the focal plane is displaced by the piezo element for focusing. By contrast with known focusing arrangements, the camera is not focused by moving the lens. The lens can be fixed to the camera housing, where the risk of outside influences affecting the lens can be excluded as much as possible. The housing protects the camera from environmental effects. This can include environmental effects such as moisture, dust, aerosols, wind, radiation, electrostatic discharges or mechanical shocks.

For focusing the reciprocal piezo effect of the piezo element is used. If a voltage is applied to a piezoelectric material, the material is mechanically deformed. The piezo element is arranged below the sensor. The mechanical deformation enables the sensor lying on the piezo element, i.e. the focal plane, to be moved in parallel to the lens. Focusing can consequently be controlled by moving the focal plane depending on the voltage applied.

With the present invention a piezo element can be used to move the focal plane since a movement of only a few 10 μm, e.g. ± 50 μm, is required. Consequently, in accordance with the invention a piezo element of known reliability, precision and stability can be used. Piezo elements have the advantage of consuming only relatively little current. Piezo elements only consume current when the voltage applied to them is changed. At a constant voltage practically no current is consumed. The main power consumption is through loss of energy from the current converter. This makes piezo elements the obvious choice for mobile applications.

In a preferred embodiment of the present invention the connecting elements for making contact with the sensor are embodied as cables, wires or bond wires. Wire bonding connections are used in particular. In this case the connecting elements provide a connection between the sensor and a circuit board or a flexible circuit board (flex foil).

In accordance with the invention the connecting elements are embodied in such a way that it is possible to move the sensor in parallel to the lens. Contact is made with the sensor in this case on two opposite sides using the bond wires.

The connecting wire is preferably bonded to the sensor. Other connecting options such as direct connection (bonding, gluing or similar) of flexible leads between sensor and circuit board/connecting flex can be provided. The bond wires preferably have so much free play that a maximum deformation of the piezo element is not restricted by the cable and a sufficiently long life of the bond connection remains guaranteed with an active piezo element.

In a further preferred embodiment the connecting elements are embodied as at least one flex foil. Preferably the flex foil consists of a Polyamide substrate with a copper foil cladding and an isolation layer of Polyamide as a covering layer

The flex foil is preferably a thin design. A thickness of flex foil of less than 34 $\mu$m proves advantageous.

Preferably the sensor is arranged on the connecting elements.

In a further embodiment of the present invention the connecting elements (e.g. a flex foil) feature two elliptical cutouts. The connecting elements in this case are fixed to the camera housing at the edge and arranged over the piezo element in the connecting area with the sensor. Embodying the connecting elements as a flex foil allows low-cost and stable contact to be made with the sensor. In addition an optimum function of the camera is guaranteed after a large number of focusing cycles.

In a further embodiment of the present invention the camera features an infrared filter.

Further the camera can feature a protective glass cover over the lens.

In a further development of the present invention the camera is combined with an autofocus control. The present invention thus makes autofocusing possible for miniaturized cameras. For this a corresponding algorithm must take over the control of the piezo element. Such an algorithm can for example be integrated into the image processor of the camera.

The invention is explained in greater detail below with reference to the enclosed drawing on the basis of exemplary embodiments. The features shown in the drawings and also the features already described above can be of importance for the invention not only in the said combination but also individually or in other combinations. The diagrams show:

Figure 1 a schematic diagram of a camera in accordance with the invention with connecting bond wires;

Figure 2 a schematic diagram of a camera in accordance with the invention with a flexible connection as its connecting element; and

Figure 3 a diagram of a flex foil in accordance with the present invention.

Figure 1 shows an exemplary embodiment of a camera in accordance with the invention. The camera features a protective glass cover 1, a focusing lens 2 and an infrared filter 3. The lens 2 is fixed to the housing 7 with a frame 14. The lens 2 cannot be moved. The sensor 4 represents the focal plane The piezo element 5 which is located on a circuit board 6 is arranged below the lens. With the aid of the bond wires 10 a connection is provided between the sensor 4 and the circuit board 6. The application of a voltage (not shown) to the piezo element deforms the latter in a vertical direction (as indicated by the arrow) so that the sensor lying on it, i.e. the focal plane of the camera, rises or falls. The camera can thus be focused by changing the voltage at the piezo element 5. The wires 10 can be bonded to the sensor 4 in this case.

Figure 2 shows a second exemplary embodiment of the present invention. The camera in Figure 2 again includes a protective glass cover 1, a focusing lens 2 and an infrared filter 3. The lens 2 is

again fixed to the housing 7 via frame 14. Contact with sensor 4 is made in the exemplary embodiment in accordance with Figure 2 using a thin flex foil 12. The sensor 4 is on the flex foil 12 in this case. By applying a voltage (not shown) to the piezo element 5 the sensor 4 on the flex foil 12, i.e. the focal plane of the camera, can be raised or lowered. The camera can thus be focused depending on the voltage applied.

Figure 3 shows a view from above in accordance with the invention of the layout of a flex foil in accordance with Figure 2. The sensor 4 lies in the central area of the flex foil 11 on the foil. The flex foil features two elliptical cutouts 13. In the area of the connecting ends 12 of the flex foil 11, i.e. under the sensor 4, the piezo element (not visible in Figure 3) is located. in the edge area of flex foil 11, i.e. around the cutouts 13 the flex foil 11 is connected with the underside of the housing 7. The elliptical embodiment of the cutouts 13 is not mandatory in this case.

With all embodiments it is conceivable for the protective glass covers above the lens and/or depending on the system, also the infrared blocking filter to be omitted.

The present invention makes it possible to provide adjustable focus in a camera largely protected from environmental effects. Known miniature cameras can in this case be kept the same size but the field of application of camera increased.

In addition there are advantages when assembling the camera, since no small precise fine adjustment tolerances are needed for arranging the lens. A relatively rough adjustment of the lens is sufficient. The camera can be focused correctly manually by the user.

This has a significant influence on the manufacturing costs of such a camera in series production.

Furthermore temperature compensation of the focus adjustment can be implemented with such a system. Conventional camera constructions must take account of the effects of the different working temperatures in the construction of the housing. This can only be done to a limited extent or at significant expense. Thus the costs of a camera module can be reduced by the present invention.

The present invention can basically be combined with any type of autofocus control, so that autofocus functionality is provided. Better protection against dust is possible by comparison with known autofocus concepts.